Hydrodynamics of low-dimensional interacting systems: Advances, challenges, and future directions

Report of Contributions

https://indico.yukawa.kyoto-u.ac.jp/e/hydro2025

Contribution ID: **1** Type: **not specified**

Lectures: Generalized hydrodynamics of the Toda fluid

Monday, June 2, 2025 1:45 PM (1h 30m)

The hydrodynamics of integrable many-body systems has accomplished spectacular advances. In my lectures, I will use the famous Toda chain to illustrate the main features of generalized hydrodynamics. Key items are generalized Gibbs ensembles, their connection to random matrix theory, average charges and currents,TBA equations, and scattering coordinates as yielding large deviations.

Presenter: SPOHN, Herbert

Contribution ID: **2** Type: **not specified**

Lectures: Generalized hydrodynamics of the Toda fluid

Tuesday, June 3, 2025 9:30 AM (1h 30m)

The hydrodynamics of integrable many-body systems has accomplished spectacular advances. In my lectures, I will use the famous Toda chain to illustrate the main features of generalized hydrodynamics. Key items are generalized Gibbs ensembles, their connection to random matrix theory, average charges and currents, TBA equations, and scattering coordinates as yielding large deviations.

Presenter: SPOHN, Herbert

Contribution ID: **3** Type: **not specified**

Energy diffusion in the long-range interacting spin systems

Tuesday, June 3, 2025 11:30 AM (45 minutes)

We investigate energy diffusion in long-range interacting spin systems, where the interaction decays algebraically as $V(r) \propto r^{-\alpha}$ with the distance r between the sites. We consider prototypical spin systems, the transverse Ising model, and the XYZ model in the D-dimensional lattice with a finite exponent $\alpha > D$ which guarantees the thermodynamic extensivity. In one dimension, both normal and anomalous diffusion are observed, where the anomalous diffusion is attributed to anomalous enhancement of the amplitude of the equilibrium current correlation. We prove the power-law clustering property of arbitrary orders of joint cumulants in general dimensions. Applying this theorem to equal-time current correlations, we further prove several theorems leading to the statement that the sufficient condition for normal diffusion in one dimension is $\alpha > 3/2$ regardless of the models. The fluctuating hydrodynamics approach consistently explains L\'{e}vy diffusion for $\alpha < 3/2$, which implies the condition is optimal. In higher dimensions of $D \geq 2$, normal diffusion is indicated as long as $\alpha > D$. [1] [1] HN and K.Saito, arXiv:2502:10139

Presenter: NISHIKAWA, Hideaki

Contribution ID: **5** Type: **not specified**

The Kardar-Parisi-Zhang universality class for driven interfaces and… integrable spin chains?

Wednesday, June 4, 2025 9:30 AM (1h 30m)

The Kardar-Parisi-Zhang (KPZ) universality class, originally formulated to describe driven systems such as growing interfaces, has undergone several paradigm shifts. One major breakthrough was the discovery of exact solutions for the 1D KPZ class, achieved thanks to its underlying integrability [1]. However, more recently, the KPZ framework appears to be entering a new phase, extending unexpectedly to integrable spin chains at thermal equilibrium [2]. Although this connection was nearly dismissed when clear discrepancy in full counting statistics was reported, the speaker and collaborators numerically found that various two-point quantities agree precisely with KPZ exact solutions [3], even though higher-order quantities remain clearly different.

In my talk, I will first review some of the main outcomes of the 1D KPZ exact solutions, often referring to the corresponding experimental observations that the speaker and collaborators have reported [1]. Then I will present our recent numerical results on integrable spin chains, showing the aforementioned partial yet definite emergence of the KPZ class therein [3]. This partial emergence of the KPZ class is yet to be understood; therefore, this talk will serve as an introduction to the discussion session scheduled in the afternoon.

[1] For a review, see, e.g., K. A. Takeuchi, Physica A 504, 77 (2018).
[2] For reviews, see, e.g., V. B. Bulchandani et al., J. Stat. Mech. (2021), 084001; S. Gopalakrishnan and R. Vasseur, Annu. Rev. Condens. Matter Phys. 15, 159 (2024).
[3] K. A. Takeuchi, et al., Phys. Rev. Lett. 134, 097104 (2025).

Presenter: TAKEUCHI, Kazumasa

Contribution ID: **6** Type: **not specified**

From integrable spin chains to coupled KPZ equations

Wednesday, June 4, 2025 11:30 AM (1h 30m)

Surprising signatures of anomalous spin transport have been reported in the spin-half Heisenberg spin chain at the isotropic point, in a number of recent works. The talk will discuss: (i) analogous results for classical integrable spin chains and (ii) properties of coupled Burgers equations that have been proposed as effective hydrodynamic descriptions of integrable spin chains.

Presenter: DHAR, Abhishek

Contribution ID: **7** Type: **not specified**

Quantum dynamics and entanglement in open systems

Thursday, June 5, 2025 9:30 AM (1h 30m)

I will discuss Page-curve entanglement dynamics between a system and its environment under various scenarios. In particular, I will discuss an analytically tractable model of a gas of noninteracting fermions on a lattice that is released from a box into the vacuum [1]. I will then discuss the dynamics of entanglement in a one-dimensional XXZ spin-1/2 chain [2], with and without integrability-breaking interactions, that is connected to a bath. Finally, I will discuss quantum dynamics when particles are injected into systems that are either subjected to dephasing mechanisms or are themselves interacting [3].

[1] M. Saha, M. Kulkarni, A. Dhar, Phys. Rev. Lett. 133, 230402 (2024)
[2] T. Ray, A. Dhar, M. Kulkarni, arXiv:2504.14675 (2025)
[3] T. Ray, K. Ganguly, M. Kulkarni, B. Agarwalla (manuscript in preparation)

Presenter: KULKARNI, Manas

Contribution ID: **8** Type: **not specified**

Coherent transport: Thermodynamic uncertainty relations and large deviation analysis

Thursday, June 5, 2025 2:15 PM (45 minutes)

We derive a universal thermodynamic uncertainty relation for Fermionic coherent transport, which bounds the total rate of entropy production in terms of the mean and fluctuations of a single particle current. This bound holds for any multi-terminal geometry and arbitrary chemical and thermal biases, as long as no external magnetic fields are applied. It can further be saturated in two-terminal settings with boxcar-shaped transmission functions and reduces to its classical counterpart in linear response. Upon insertion of a numerical factor, our bound also extends to systems with broken time-reversal symmetry. As an application, we derive trade-off relations between the figures of merit of coherent thermoelectric heat engines and refrigerators, which show that such devices can attain ideal efficiency only at vanishing mean power or diverging power fluctuations. To illustrate our results, we work out a model of a coherent conductor consisting of a chain of quantum dots.

Presenter: SAITO, Keiji

Contribution ID: **9** Type: **not specified**

Speed limits and optimal transport: General bounds and maximal speed of particle transport

Thursday, June 5, 2025 11:30 AM (1 hour)

Presenter: VU, Tan Van

Contribution ID: **10** Type: **not specified**

Macroscopic fluctuation theory on a lattice and its connection to classical integrable systems

Thursday, June 12, 2025 9:30 AM (1h 30m)

Macroscopic fluctuation theory (MFT) is a general theory for studying large deviations of interacting particle systems. A central object in the theory is the MFT equations, whose solution gives the rate function for certain rare events. A few years ago, we have found a mapping from the MFT equations for the symmetric simple exclusion process to the AKNS system, which is a well-known classical integrable system [1]. In this talk we first review this and discuss a lattice version of the theory.

In recent years several interacting particle systems which have a parameter called a "spin"have been introduced and studied. They include the partial exclusion process, inclusion process and the harmonic model. For this class of models, we propose a new type of large deviation for large spin. We first explain the basic formulation based on the scheme of Feng-Kurtz and calculate the associated Hamiltonian for a few examples. We also discuss connections to the conventional macroscopic fluctuation theory (MFT) and show how one can calculate the rate function exactly by mapping to a classical integrable system on a lattice.

The talk is based on collaborations with Cristian Giardina, Hayate Suda, Kirone Mallick and Hiroki Moriya.

Reference:
[1] K. Mallick, H. Moriya, T. Sasamoto,
Exact solution of the macroscopic fluctuation theory for the symmetric exclusion process,
Phys. Rev. Lett. 118, 160601 (2022).

Presenter: SASAMOTO, Tomohiro

Contribution ID: **11** Type: **not specified**

Kinetic theory of moderately dense dry granular particles under a simple shear

Friday, June 6, 2025 12:15 PM (45 minutes)

We formulate the kinetic theory of dry granular particles under a simple shear based on the Enskog and Grad approximations. We get a complete set of equations for the kinetic stress and the collisional contribution to the stress within this approximation. The steady solution under this approximation reproduces the quantitatively accurate results for the shear viscosity and kinetic temperature for the volume fraction $\varphi < 0.5$ except for the case of nearly elastic situations. We also get qualitatively accurate results for the steady normal stress differences for $\varphi < 0.5$. By using a protocol of reversing a shear rate satisfying Newton's equation of motion, we also discuss the relaxation dynamics to reach the steady state. We observe the Kovacs effect in a wide range of parameters and Mpemba effect if the initial conditions of two copied systems are not largely deviated. This is based on the collaboration with Shunsuke Iizuka and Satoshi Takada.

Presenter: HAYAKAWA, Hisao

Contribution ID: **12** Type: **not specified**

Mean-field theory becomes exact under shear flow: A dynamic renormalization group study of the O(n) model

Friday, June 6, 2025 10:15 AM (45 minutes)

Mean-field theory, such as Landau theory, provides a simple yet powerful framework for understanding critical phenomena. However, in equilibrium systems, its predictions often fail in low dimensions: the upper critical dimension is typically four, and significant deviations in critical exponents are observed in two and three dimensions. Intriguingly, experiments on phase separation under shear flow and recent simulations of spin models have reported mean-field-like critical exponents even in two dimensions [1, 2]. These findings suggest that shear flow may fundamentally alter the nature of critical behavior, effectively lowering the upper critical dimension. To uncover the physical mechanism behind this phenomenon, we performed a dynamic renormalization group analysis of the O(n) model under simple shear flow [3]. A key innovation of our work is the explicit treatment of shear-induced anisotropy in the scaling analysis—an aspect neglected in earlier studies [4]. Our results reveal the existence of a novel Gaussian fixed point governed by strong anisotropy due to shear. Strikingly, we find that the upper critical dimension of this fixed point is reduced to two or lower for both conserved and non-conserved dynamics. This implies that mean-field theory becomes asymptotically exact in all dimensions except one. [1] D. Beysens, M. Gbadamassi, and L. Boyer Light-Scattering of a Critical Mixture with Shear Flow, Phys.Rev.Lett. 43 (1979) 1253 [2] H. Nakano, Y. Minami, and S. Sasa Long-Range Phase Order in Two Dimensions under Shear Flow, Phys.Rev.Lett. 126 (2021) 1606 04 [3] H. Ikeda, and H. Nakano, Dynamical renormalization group analysis of O(n) model in steady shear flow, arXiv:2412.02111 (2024) [4] A. Onuki, and K. Kawasaki, Nonequilibrium Steady State of Critical Fluids under Shear Flow: A Renormalization Group Approach, Ann. Phys. 121 (1979) 456

Presenter: IKEDA, Harukuni

Contribution ID: **13** Type: **not specified**

Looking at bare transport coefficients in fluctuating hydrodynamics

Monday, June 9, 2025 12:15 PM (45 minutes)

It is well established that fluid motions at the macroscopic scale are governed by the celebrated Navier-Stokes equation. However, in mesoscopic regimes where fluctuations become significant, the governing equations must incorporate fluctuation terms, leading to the framework of "fluctuating hydrodynamics" [1]. A central feature of this framework is the presence of noise terms and associated transport coefficients, referred to as bare transport coefficients. These coefficients characterize dissipation and transport at the mesoscopic scale and differ from the macroscopic transport coefficients of the deterministic Navier-Stokes equation, which govern macroscopic fluid phenomena. Particularly in two-dimensional (2D) fluids, this distinction between the bare and macroscopic transport coefficients is crucial [2]. The macroscopic coefficients depend on system size and diverge logarithmically as the system size increases, while the bare coefficients are expected to remain finite constants determined by microscopic details such as atomic structure, temperature, and pressure (or density). However, directly measuring the bare transport coefficients has proven challenging because standard observations typically yield only the macroscopic ones. In our recent paper [3], we address this challenge. We show how bare transport coefficients manifest in measurable physical quantities and propose practical methodologies for their determination. In this presentation, we will explain our results, presenting both numerical simulation results and theoretical calculations. [1] L. D. Landau and E. M. Lifshitz, Fluid Mechanics: Volume 6 (Elsevier, 1959) [2] D. Forster, D. R. Nelson, and M. J. Stephen, Physical review. A 16, 732 (1977). [3] H. Nakano, Y. Minami, and K. Saito, arXiv:2502.15241 (2025).

Presenter: NAKANO, Hiroyoshi

Contribution ID: **14** Type: **not specified**

Steady velocity of entropic driven interface in shear flow

Friday, June 6, 2025 11:30 AM (45 minutes)

When different two phases come into contact through a flat interface, the interface moves in a certain direction, and its steady-state velocity is determined by the driving force caused by the difference in free energy between the two phases and the mobility. When describing interface phenomena using the probabilistic order parameter field model, which is Model A of Hohenberg and Halperin(1977), a new interface driving force arises due to entropic contributions from noise and asymmetric shape of free energy density. We refer to such an interface as an "entropic driven interface". We investigate the steady-state velocity of planer entropic driven interfaces parallel to the flow by the Model A. We decompose the interface driving force into components in the bulk and at the interface, and derive the velocity formula. We also perform numerical calculations to verify the validity of the formula.

Presenter: KADO, Yutaro

Contribution ID: **15** Type: **not specified**

Lectures: Generalised hydrodynamics: exact solutions, fluctuations, and all-order expansion

Monday, June 9, 2025 9:30 AM (1h 30m)

Hydrodynamics is more than a set of PDES. It is a framework for emergent dynamical behaviour in many-body systems. Generalised hydrodynamics (GHD), with its exact equations and rich structure, has led to a much deeper understanding of this framework.

Lecture 1: Following on from Herbert's talk, I will explain the general features of GHD for classical and quantum systems, focusing on the quantum Lieb-Liniger model. This includes: the hydrodynamic equation and its linear response, GHD as a dressed classical kinetic theory, a geometric mapping to freely propagating waves, wave-packet / soliton gas relation, exact solutions, Hamiltonian form, and general solvability theorems.

Lecture 2: I will come back to the fundamental concepts at the basis of hydrodynamics, putting the Mori-Zwanzig projection idea on a firmer basis. This gives a full theory of non-linear response, typical and large-deviation form of fluctuations, emergent hydrodynamic noise and why it is absent in integrable models, and all-order hydrodynamic expansion.

Presenter: DOYON, Benjamin

Contribution ID: **16** Type: **not specified**

Unified description of hydrodynamic and Nambu–Goldstone modes in open and closed systems

Monday, June 9, 2025 11:30 AM (45 minutes)

I present a unified effective theory of hydrodynamic and Nambu–Goldstone (NG) modes in both closed and open systems. A central focus is the distinction between strong and weak symmetries, which clarifies how NG modes can emerge even in the absence of conserved charges, as in open systems. Using the Schwinger–Keldysh formalism, I classify NG modes and derive their dispersion relations, including both type-A and type-B modes.

Presenter: HIDAKA, Yoshimasa

Contribution ID: **18** Type: **not specified**

Fluctuations and correlations in hard-rod gas

Tuesday, June 10, 2025 9:30 AM (1h 30m)

Presenter: KUNDU, Anupam

Contribution ID: **19** Type: **not specified**

Exact expression of multifractal dimension on the non-Hermitian Cayley tree

Tuesday, June 10, 2025 11:30 AM (45 minutes)

Multifractal analysis is a powerful tool for characterizing the localization properties of wave functions. Despite its utility, this tool has been predominantly applied to disordered Hermitian systems. Multifractal statistics associated with the non-Hermitian skin effect remain largely unexplored. Here, we demonstrate that the tree geometry induces multifractal statistics for the single-particle skin states on the Cayley tree by deriving the analytical expression of multifractal dimensions. This sharply contrasts with the absence of multifractal properties for conventional single-particle skin effects in crystalline lattices. Our work uncovers the unique feature of the skin effect on the Cayley tree and provides a novel mechanism for inducing multifractality in open quantum systems without disorder. [1] Phys. Rev. B 111, 075162 (2025) [2] Phys. Rev. B 111, 035144 (2025)

Presenter: HAMANAKA, Shu

Contribution ID: **20** Type: **not specified**

Kinetic predictions for the blast in cold gas

Tuesday, June 10, 2025 12:15 PM (45 minutes)

I will present our recent (ongoing) work on understanding blast in cold gas of hard discs in two dimensions. We are able to make some theoretical estimates for quantities of interest in the hydrodynamic limit and test them using simulations.

Presenter: KUMAR, Umesh

Contribution ID: **21** Type: **not specified**

Lectures: Generalised hydrodynamics: exact solutions, fluctuations, and all-order expansion

Wednesday, June 11, 2025 9:30 AM (1h 30m)

Hydrodynamics is more than a set of PDES. It is a framework for emergent dynamical behaviour in many-body systems. Generalised hydrodynamics (GHD), with its exact equations and rich structure, has led to a much deeper understanding of this framework.

Lecture 1: Following on from Herbert's talk, I will explain the general features of GHD for classical and quantum systems, focusing on the quantum Lieb-Liniger model. This includes: the hydrodynamic equation and its linear response, GHD as a dressed classical kinetic theory, a geometric mapping to freely propagating waves, wave-packet / soliton gas relation, exact solutions, Hamiltonian form, and general solvability theorems.

Lecture 2: I will come back to the fundamental concepts at the basis of hydrodynamics, putting the Mori-Zwanzig projection idea on a firmer basis. This gives a full theory of non-linear response, typical and large-deviation form of fluctuations, emergent hydrodynamic noise and why it is absent in integrable models, and all-order hydrodynamic expansion.

Presenter: DOYON, Benjamin

Contribution ID: **22** Type: **not specified**

Signatures of integrability/non-integrability in two-dimensional quantum spin systems: local conserved quantities, operator growth, and complex-time evolution

Wednesday, June 11, 2025 11:30 AM (1h 30m)

In the first part of the talk, I will discuss our recent result on the absence of local conserved quantities in a wide class of standard S=1/2 quantum spin systems in two or higher dimensions. This is an extension of Shiraishi's 2019 work on spin chains. I will also discuss related observations about the absence of quasi-local conserved quantities and spectrum generating algebra.
In the second part, I will discuss closely related (but essentially different) problems of operator growth. We shall present some rigorous results for the Lanczos coefficients that are consistent with the universal operator growth hypothesis of Parker, Cao, Avdoshkin, Scaffidi, and Altman. More precisely, we prove that the Kitaev honeycomb model exhibits the behavior expected for an integrable model, while the XY or the Heisenberg model exhibits the behavior expected in quantum chaotic systems. We shall also discuss the related problem of complex-time evolution of operators.
The present talk is mostly based on my joint work with Naoto Shiraishi.

Presenter: TASAKI, Hal

Contribution ID: **23** Type: **not specified**

Jamming of deformable foams

Wednesday, June 11, 2025 3:15 PM (45 minutes)

The jamming transition of soft athermal particles has long been explored by numerical models of undeformable spheres/circles and the researchers have extensively studied the critical behavior of the particles near jamming. It is now well known that the shear modulus of undeformable particles scales as the square root of the proximity to the jamming transition density. However, the square-root scaling of the shear modulus has never been validated experimentally and one questions whether "deformability" of the particles alters the critical scaling. In this study, we numerically investigate the jamming transition of deformable foams to examine the influence of deformability. We show that the critical scaling of pressure, elastic energy, and excess coordination number is well established and the vibrational density of states (VDOS) exhibits a plateau above a characteristic frequency. We also examine the finite size scaling of shear modulus to clarify the effect of deformability.

Presenter: SAITOH, Kuniyasu

Contribution ID: **24** Type: **not specified**

Colloquium: Kardar-Parisi-Zhang equation: one and two components

Thursday, June 12, 2025 3:30 PM (1h 30m)

The KPZ equation was first written down in 1985 and has a rich history, reaching physical applications beyond the originally envisioned surface growth. In my lecture, I will discuss recent advances. Amongst others, they include the extension to two components and the riddle of the space-time spin-spin correlations of the Heisenberg spin chain.

Presenter: SPOHN, Herbert

Contribution ID: **25** Type: **not specified**

Macroscopic particle transport in dissipative long-range bosonic systems

Monday, June 9, 2025 2:30 PM (45 minutes)

The speed limit for macroscopic particle transport is one of the central topics in quantum mechanics, which quantifies the minimum time required for a given number of particles to propagate to a reachable regime. Recently, there are constant progress on maximal bosonic particle transport speed in Bose-Hubbard model and long-range bosonic models. However, the existing findings are limited to closed quantum systems. Due to intrinsic chemical reactions, coulping to the external environment and inelastic collisions between particles, these systems are usually not strictly closed and inevitably suffer from dissipation, such as dephasing and particle loss. The dissipation leads to the breakdown of traditional macroscopic particle transport theory. In this work, we determine the maximal speed of macroscopic particle transport in dissipative bosonic systems featuring both long-range hopping and long-range interactions. By developing a generalized optimal transport theory for open quantum systems, we rigorously establish the relationship between the minimum transport time and the source-target distance, and investigate the maximal transportable distance of bosons. We demonstrate that optimal transport exhibits a fundamental distinction depending on whether the system experiences one-body loss or multi-body loss. Furthermore, we present the minimal transport time and the maximal transport distance for systems with both gain and loss. We observe that even an arbitrarily small gain rate enables transport over long distances if the lattice gas is dilute. Moreover, we generally reveal that the emergence of decoherence-free subspaces facilitates the long-distance and perfect transport process. We also derive an upper bound for the probability of transporting a given number of particles during a fixed period with one-body loss. We also discuss ossible experimental protocols for observing our theoretical predictions.

Presenter: LI, Hongchao

Contribution ID: **26** Type: **not specified**

Efimov effect at the Kardar-Parisi-Zhang roughening transition

Wednesday, June 4, 2025 2:30 PM (1h 30m)

I would like to give a short talk on my personal interest in the roughening transition of the KPZ system in relation to the Efimov effect (discrete scale invariance).

Presenter: NAKAYAMA, Yu

Contribution ID: **27** Type: **not specified**

On the dynamical origin of the vorticity alignment in homogeneous and isotropic turbulence

Friday, June 6, 2025 9:30 AM (45 minutes)

Since the 1980s it has been known that in incompressible homogeneous and isotropic turbulence the vorticity vector tends to align with one of the eigen-directions of the rate-of-strain tensor, specifically the one associated with its intermediate (second largest) eigenvalue. Despite extensive studies, the underlying mechanism of the preferential alignment is not fully understood. In this work, making use of a three-dimensional polar representation of the equation for the velocity gradient tensor obtained before, we explore the alignment mechanism theoretically and numerically combined with the direct numerical simulation of the Navier–Stokes equations.

Presenter: MATSUMOTO, Takeshi

Contribution ID: **28** Type: **not specified**

Self-consistent method to predict trapped states in Vlasov systems

Friday, June 13, 2025 9:30 AM (45 minutes)

A Vlasov system describes dynamics of a many-body long-range interacting Hamiltonian system including self-gravitating systems and plasmas. Such a system does not go to thermal equilibrium and is trapped at a so-called quasi-stationary state. A central issue is then to predict the trapped state, which may experience a bifurcation by varying a parameter. The self-consistent method is a powerful tool to reveal universality of bifurcations. This talk presents the idea of the self-consistent method and some applications with strange universality.

Presenter: YAMAGUCHI, Yoshiyuki

Contribution ID: **29** Type: **not specified**

Opening remarks

Monday, June 2, 2025 1:30 PM (10 minutes)

Presenter: HAYAKAWA, Hisao

Contribution ID: **30** Type: **not specified**

Quantum dynamics in Krylov space: from tridiagonal matrices to quantum chaos

Wednesday, June 11, 2025 2:30 PM (45 minutes)

The dynamics of quantum systems typically unfolds within a subspace of the state or operator space, known as the Krylov space. Krylov subspace methods provide a compact and computationally efficient description of quantum evolution and quantum chaos, which is particularly useful for describing nonequilibrium phenomena of many-body systems with a large Hilbert space. In this talk, I will explore the notion of Krylov complexity as a probe for operator growth and quantum chaos, scrambling, and quantum state evolution. Illustrative examples include quantum spin chains, Sachdev-Ye-Kitaev models, and random matrix theory. The talk is based on selected topics from the review article arXiv:2405.09628 (Physics Reports).

Presenter: NANDY, Pratik

Contribution ID: **31** Type: **not specified**

Size-independent shear viscosity from equilibrium fine-grained shear stress correlations in two dimensional molecular dynamics simulations

Tuesday, June 10, 2025 2:30 PM (45 minutes)

Presenter: YOKOTA, Kazuma

Contribution ID: **32** Type: **not specified**

Exact steady states and fragmentation-induced relaxation in the no-passing asymmetric simple exclusion process

Friday, June 13, 2025 10:45 AM (45 minutes)

Abstract:
We introduce a multi-species generalization of the asymmetric simple exclusion process (ASEP) with a "no-passing" constraint, forbidding overtaking, on a one-dimensional open chain. This no-passing rule fragments the Hilbert space into an exponential number of disjoint sectors labeled by the particle sequence, leading to relaxation dynamics that depend sensitively on the initial ordering. We construct exact matrix-product steady states in every particle sequence sector and derive closed-form expressions for the particle-number distribution and two-point particle correlation functions. In the two-species case, we identify a parameter regime where some sectors relax in finite time while others exhibit metastable relaxation dynamics, revealing the coexistence of fast and slow dynamics and strong particle sequence sector dependence. Our results uncover a novel mechanism for non-equilibrium metastability arising from Hilbert space fragmentation in exclusion processes.

Presenter: MIURA, Urei

Contribution ID: **33** Type: **not specified**

Closing remark

Friday, June 13, 2025 11:30 AM (10 minutes)

Presenter: DHAR, Abhishek